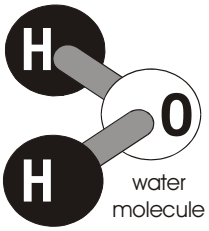
ELEMENTARY/INTERMEDIATE **ARTICLE: Hydrogen**



Hydrogen is the simplest element known to man. Hydrogen as a gas (H_2) doesn't exist on earth. It is always attached to other elements. Combined with oxygen, it is water (H_2O). Combined with carbon, it makes different compounds such as methane (CH_4), coal, and petroleum. Hydrogen is also found in all growing things—biomass.

Most of the energy we use today comes from fossil fuels. Only about six percent comes from renewable energy sources. But people want to use more renewable energy. It is usually cleaner and is replenished in a short period of time. Renewable energy sources—like solar and wind—can't produce energy all the time. Renewable sources can't always make energy when or where we need it. Hydrogen can store energy until it's needed and move it to where it's needed.

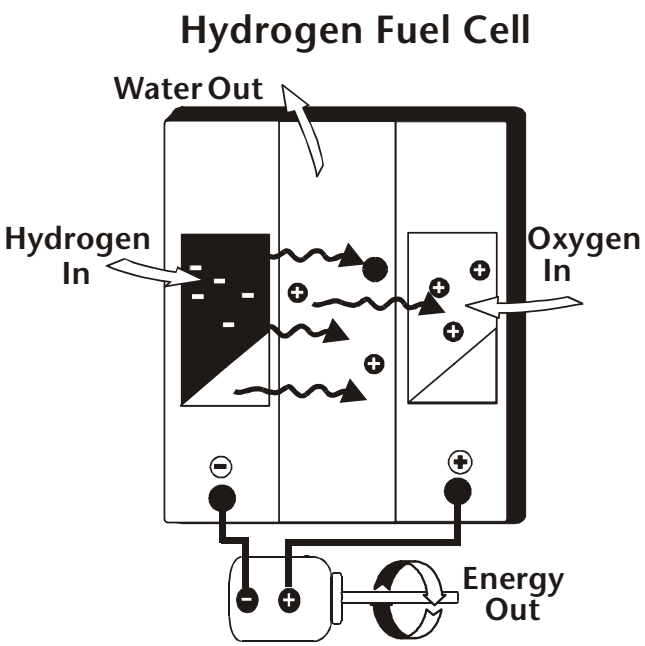
Every year, we use more energy to make electricity. Electricity is a secondary source of energy. Secondary sources of energy—sometimes called **energy carriers**—store, move, and deliver energy to consumers. We convert energy to electricity because it is easier for us to move and use. Life would be really hard if we had to burn the coal, split the atoms, or build our own dams. Energy carriers make life easier.

Hydrogen is an energy carrier for the future. It is a clean, renewable fuel that can be used in places where it's hard to use electricity. Sending electricity a long way over power lines costs much more than shipping hydrogen by pipeline.

Since hydrogen doesn't exist on earth as a gas, we must make it. We make hydrogen by separating it from water, biomass, natural gas or coal. Scientists have even discovered that some algae and bacteria give off hydrogen. It's very expensive to make hydrogen right now, but new technologies are being developed all the time.

NASA has used hydrogen for years in the space program. Hydrogen fuel lifts the space shuttle into orbit. Hydrogen batteries—called **fuel cells**—power the shuttle's electrical systems. The only by-product is pure water, which the crew uses as drinking water.

Hydrogen fuel cells make electricity. They are very efficient, but expensive to build. Some day, small fuel cells could power electric cars. Large fuel cells could provide electricity in remote areas. Because of the cost, hydrogen power plants won't be built for quite a while. Hydrogen may soon be added to natural gas, though, to reduce pollution from existing power plants.



Hydrogen can also be added to gasoline to reduce pollution. Adding just five percent hydrogen to gasoline can significantly lower emissions of nitrogen oxides (NO_x), which contribute to ground-level ozone pollution. An engine that burns pure hydrogen produces almost no pollution. It will probably be 20 years, though, before you can walk into your local car dealer and drive away in a hydrogen-powered car.

Before hydrogen can take its place in the U.S. energy picture, many new systems must be built. We will need systems to make hydrogen, store it, and move it. We will need pipelines and fuel cells. And consumers will need the technology and the education to use it.

The goal of the U.S. Department of Energy's Hydrogen Program is for hydrogen to produce ten percent of our energy by the year 2030. Hydrogen could provide clean, renewable energy for the future.

ELEMENTARY/INTERMEDIATE EXPLORATION: Electrolysis

Background: Electrolysis is the process of using an electric current to separate water molecules into hydrogen (H_2) and oxygen (O_2) gases. H_2O is the formula for water. Every molecule of water has two atoms of hydrogen and one atom of oxygen.

Materials:
100 milliliters (ml) warm water
2 cubic centimeters salt (the salt helps the electric current move through the water)
6-volt battery (do not substitute another size battery)
2 sets of alligator clips and wires
2 large metal paper clips
1 small flat plastic dish
safety glasses

Procedure: Mix salt and water in dish until salt dissolves.

Bend each paper clip as shown in the diagram.

Connect one alligator clip to each battery terminal.

Connect the other ends of the alligator clips to the paper clips.

Place the two paper clips in the salt water so they do not touch.

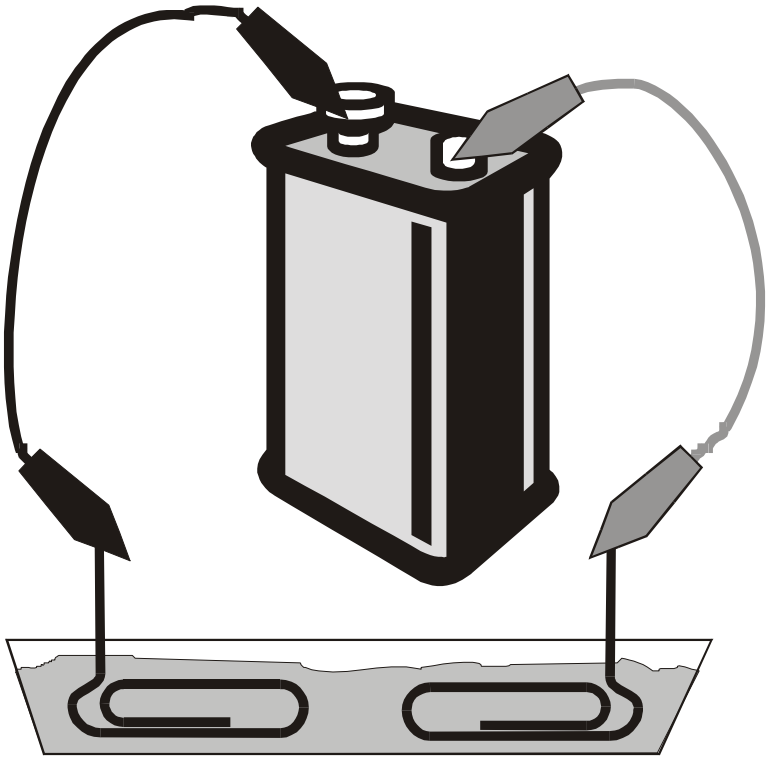
Observe the paper clips.

Results: Bubbles will form at both of the paper clips. More bubbles will form at one than the other. That is because two molecules of hydrogen (H_2) gas are produced for every molecule of oxygen (O_2) gas.

Conclusion: Which battery terminal (+ or –) produces oxygen (O_2) gas?

Which battery terminal (+ or –) produces hydrogen (H_2) gas?

Extension: If 20 molecules of water are split, how many molecules of hydrogen and how many molecules of oxygen will be produced?



Conclusion Answer: *Hydrogen: – terminal; Oxygen: + terminal*
Extension Answer: *$20\ H_2O = 20\ H_2 + 10\ O_2$*